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US ARMY
MATERIEL COMMAND

INSTRUMENTATION DEVELOPMENT

FINAL REPORT

THE VEHICULAR MOVEMENT DETECTOR METER (VMDM)

BY

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The Vehicular Movement Detector Meter (VMDM) was developed to record the forward and reverse movement time of wheeled and tracked vehicles in the in an efficient and cost effective manner. There were no failures of the instrumentation during the field testing. Bench testing showed a "full-on" state at 0.7 mph and a maximum recording speed of over 350 mph.

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FOREWORD

This rerort was prepared in accordance with TECOM Regulation (Draft) 70-18; Research, Development, and Acquisition for INSTRUMENTATION DEVELOPMENT AND ACQUISITION, 1 April 1989. It documents the development of instrumentation currently in use that measures forward or reverse vehicular movement time. This project was conducted by the Engineering Support Branch, Technical Support Division, Materiel Test Directorate, U. S. Army Yuma Proving Ground to enhance and expand the data collection capability on mobility/durability test vehicles. The assistance of technical editor, Mary Lou Wilkey, and electronics technician, Gerry Bauer, in preparing and documenting this report is acknowledged.

SECTION 1. SUMMARY

1.1 BACKGROUND

Traditionally, power-on time is the data recorded in most mobility test scenarios. Power-on time is the time period between turning on the master power switch and turning the master power switch off; or, the time period that the oil pressure switch was activated. In other words, the time the vehicle was operational during the performance of mobility tests. The time recorded with this instrumentation was with or without vehicle movement. There was a need for forward/reverse vehicle operational movement time data and idle time rather than just the power-on data.

The vehicle performance recorders (VPR) used prior to this instrumentation development project were capable of recording vehicle movement data but, they were unnecessarily complex and expensive for some tests. Therefore, a new, inexpensive device was needed to record and store vehicle movement data. The Mobility Branch of Test Engineering tasked the Engineering Support Branch to develop instrumentation for this purpose (reference Appendix A). Acquiring data exclusively representative of vehicle movement was the entire purpose of the instrumentation project. However, the instrumentation data were also applicable to average speed and operational failure statistical calculations.

This project was titled the Development of the Vehicular Movement Detector Meter (VMDM).

1.2 DESCRIPTION OF INSTRUMENTATION

The VMDM (Figure 1) is a solid state electronic hour-meter with mechanical read-out capable of measuring to tenths of an hour the forward/reverse movement time of a vehicle. Standard commercially available components were used to develop the VMDM. The VMDM consists of the following components:

- Power Regulator
- Low Power Hex Inverter Schmitt trigger
- Resistors
- Capacitors
- Diodes
- Transistors
- Dual In-line Package (DIP) Switch (4 Position)
- Electronic solid state hour-meter

FIGURE 1. Final Design. Vehicular Movement Detector Meter (VMDM)

The circuitry was designed to stretch or convert a pulsating Direct Current (DC) signal to a steady state DC level (see Appendix B for oscilloscope waveform diagrams). The steady state DC then activates a transistor which acts as an on/off switch operating a digital clock hour-meter. The activating signal may be obtained from an independent source such as VPR and tachograph transducers or it can be obtained from a switch which is powered by the VMDM.

Using a switch sending unit connected to the speedometer's flexible shaft, the meter recorded forward/reverse vehicle movement in tenths of hours. This electronic hour-meter provided data appropriate for mobility tests conducted to analyze non-movement operational times versus operational movement times in vehicles and get the actual "down time". The VMDM is powered from the vehicle electrical power bus.

1.3 OBJECTIVES

The objectives of this project were:

a. To develop instrumentation which would enhance and expand the data collection capability on mobility/durability test vehicles.

b. To develop instrumentation capable of recording actual forward/reverse movement time (in tenths of hours) of vehicles.

c. To install and test the instrument on wheeled and tracked test vehicles performing mobility/durability test scenarios to analyze performance.

1.4 SUMMARY OF RESULTS

The VMDM was designed and built to perform the required function. Tests were conducted on the prototype instrument to determine the design feasibility.

Additional tests were conducted on a re-designed model. These tests were conducted using the Vehicle Performance Recorder (VPR) or the ARGO Instruments tachograph sending units and also a switch biased by the VMDM.

Five of the re-designed instruments were built. All five of the units were used in bench testing for the "full-on" state and four of the units were installed in different 5-ton class mobility test vehicles for field testing. All five of the instruments tested functioned properly.

The bench test, using a sweep function generator to generate the activating pulse, revealed that the start state of the meter was less than 0.7 mph with a "full-on" state of 0.7 mph and a maximum recording speed of greater than 350 mph.

1.5 ANALYSIS

a. Bench Test.

The results of the bench test were satisfactory, with a "full-on" state at 0.7 mph and a maximum recording speed greater than 350 mph.

b. Field Test.

The re-designed model of the VMDM provided statistically accurate forward/reverse vehicle movement data (in tenths of hours). The design modification improved the start or "on" time of the meter from 1.4 mph to 0.7 mph.

1.6 CONCLUSION

The VMDM can perform its function efficiently. No shortcomings were noted with the design. The design of the instrument allows it to be used with other pulse generating equipment or sending units.

1.7 RECOMMENDATION

Because of the accuracy, low cost, ease of installation, and high reliability of the VMDM, it is recommended that all test vehicles use the VMDM when data of actual forward/reverse movement time are required instead of or in addition to power-on data. However, the future use of this instrumentation should not be limited to track or wheeled vehicles. The use could be extended to any rotating device capable of delivering the pulse required to operate the VMDM.

SECTION 2. DETAILS OF TASK

2.1 INTRODUCTION

The Mobility Engineering Branch of the YPG Test Engineering Division requested the development of an instrument (Vehicular Movement Detector Meter (VMDM)) for installation in mobility test vehicles to provide the capability of calculating vehicle movement time, idle time, average speed, and statistical analysis of operational failure problems. The four requirements were defined as follows:

a. Vehicle movement time -- actual time the vehicle is in motion as recorded by the VMDM.

b. Idle time -- the difference between ignition/oil pressure switch hour-meter time and VMDM accumulated time.

c. Average speed -- the actual miles driven divided by VMDM accumulated time.

d. Statistical analysis -- movement mode analysis of operational failures/problems encountered in suspension, track, wheel, automotive and frame subsystems.

Specifically, the device was required to measure the time a tracked or wheeled vehicle was in forward or reverse motion for a comparison between the time accumulated in this manner and the time accumulated with the "power on" meter to determine idle time.

A prototype VMDM (Figure 2) was designed by the Engineering Support Branch using commercially available components.

The prototype VMDM was installed in a High Mobility Multi-purpose Wheeled Vehicle (HMMWV). The installation procedure was as follows:

a. Three sending units were installed in-line with the speedometer flexible shaft. These three units were:
2 - Masstech yellow jacket reed switches (TR-8 2525-8), and
1 - ARGO Instrument 2157 Hall Effect Switch sending unit.
One of the Masstech yellow jacket switches was used to operate the Vehicle Performance Recorder (VPR). The other Masstech yellow jacket switch was used to operate the VMDM. The ARGO Instrument sending unit was installed to operate an ARGO tachograph, models 1310 or 1318.

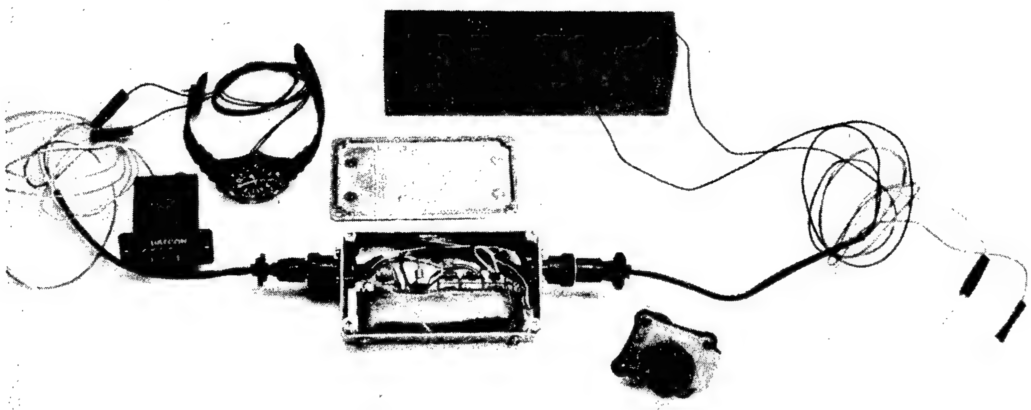


FIGURE 2. VMDM Prototype Assembly.

The HMMWV test vehicle ran a mobility test scenario over desert terrain in accordance with the prescribed test plan. The VMDM began recording at 1.4 mph. The accumulated readings were verified and checked for accuracy at the end of each operation shift. The prototype hour-meter testing discontinued after 153.5 hours when one of the speedometer flexible shaft drive tips became un-crimped presumably due to the amount of torque being applied when the pulse generating sending unit was inserted in-line with the speedometer flexible shaft.

The prototype hour-meter test proved that the instrument satisfactorily recorded the forward and reverse movement for the 153.5 hours that it was in operation. The design of the prototype instrument was satisfactory. However, it was determined that alternative methods could be used to pick up the pulse signal, by modifying the prototype circuitry. (The speedometer flexible shaft failure did not affect the test results.)

After the initial test of the prototype hour-meter, alternative methods of picking up the signal pulse were explored. The alternative methods were desirable because some mobility tests require multiple modes for recording data. These modes can include any one or more of the following combinations: VPR, VMDM, and/or tachograph.

Two tasks were initiated to modify the prototype VMDM to reduce the start or "full-on" state to below one mph and to

limit the excessive torque loads on the speedometer flexible shaft. The reduction in the "full-on" state speed was accomplished by changing capacitors in the circuitry. Limiting the excessive torque was accomplished by designing a VMDM to operate in two additional configurations (modes) for a total of three operational configurations described as follows:

a. Independent Configuration. This was the original configuration of the prototype and was retained in the re-designed instrument. It used a separate pulse sending unit and was powered by the vehicle's electrical system.

b. High Impedance Configuration. This configuration slaved off the VPR's Masstech yellow jacket switch, TR-8, sending the signal to the metering device. This configuration can also slave off the tachograph's ARGO Instruments 2157 Hall effect switch sending unit.

c. Low Impedance Configuration. This configuration was designed to use a low impedance signal device. This configuration was not tested.

The three configurations were developed and incorporated as alternative signal pick up sources in the re-designed meter. Five re-designed meters were built. Four of these meters were installed in 5-ton class vehicles undergoing mobility tests at YPG. The re-designed meter is the subject of the balance of this report.

2.2 OBJECTIVES

To develop an hour-meter capable of measuring in tenths of hours the forward and reverse movement of wheeled and tracked test vehicles. The desired characteristics are:

a. To have a "full-on" state at less than one mph.

b. To use commercially available components augmented with in-house circuit design to customize movement recording instrumentation.

c. To maintain compatibility with standard instrumentation currently used in wheeled and tracked vehicles.

d. To incorporate the features of the prototype VMDM and add alternative methods of picking up the pulse signal.

2.3 SYSTEM COMPONENTS

Standard commercially available components were used as extensively as possible in the re-designed hour-meter instrument. The following components were purchased from commercially available sources for use in the design:

1 - solid state electronic hour-meter (Dayton Instruments No. 56458-04 Model 876 12/24 VDC)
1 - 74HCT14 low power hex schmitt trigger inverter chip
1 - 7805 power regulator
1 - 2N1480 transistor
1 - 4-position DIP switch
1 - 1/2 amp fuse with holder
12 - resistors: 3 - 1k ohms, 5 - 10k ohms, 1 - 33k ohms, 1 - 3.9M ohm, and 2 - 1M ohms.
5 - capacitors: 3 - 1553 and 2 - 1535
4 - diodes 1 - 1N4733, and 3 - 1N914
1 - container box
IC sockets, wire wrapped
Header or component carriers
Wire wrap transistor socket
Vector board
Wire wrap (wire)
4 - conductor wires, shielded wiring

2.4 PROCEDURE

a. Assembly.

The components were assembled as shown in the schematic drawing in Figures 3-1 and 3-2. Room-temperature vulcanizing (RTV) silicone sealant was applied to the wire connections and the instrument housing to maintain the stability of the wire wrap circuits and prevent the infiltration of dust. The use of RTV does not allow easy reworking of the circuits or easy access to the interior of the instrument housing but the use of RTV is necessary due to dust.

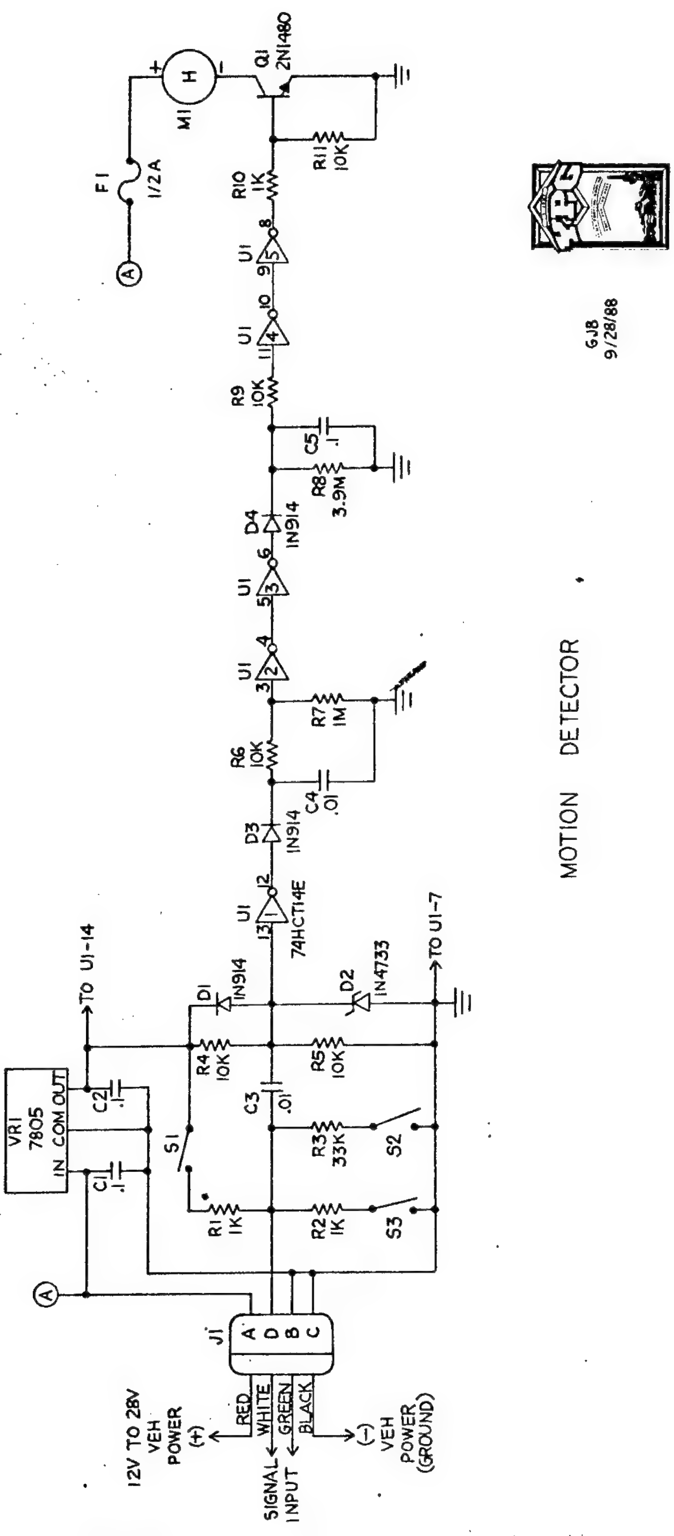


FIGURE 3-1. Schematic Drawing. VMDM.

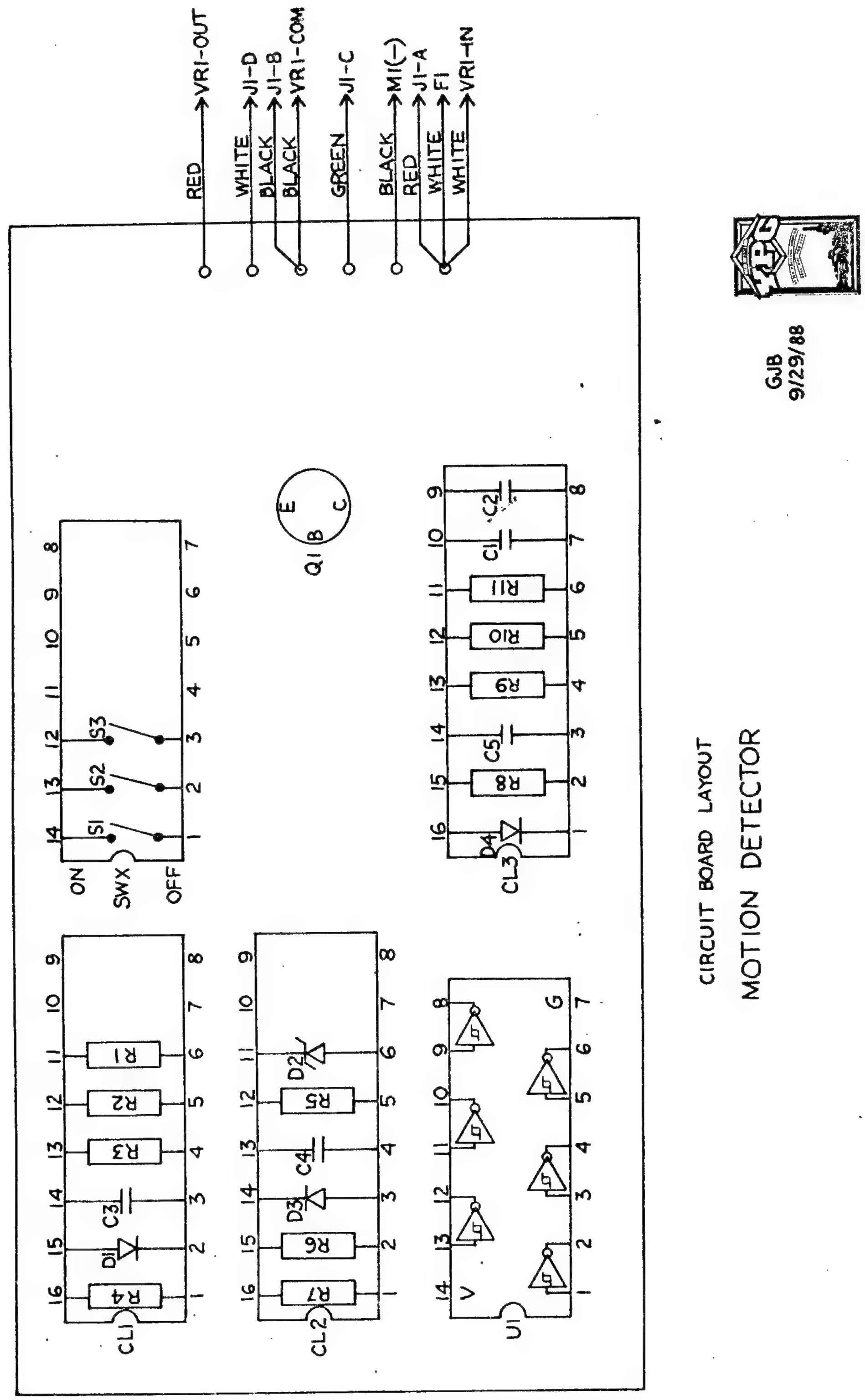


FIGURE 3-2. Physical Layout. VMDM.

b. Installation. (Full details are illustrated in Appendix C)

(1) External Wire Connections. Four conductor shielded wire hookups were used as follows.

(a) Power Hookup. 12 to 24 VDC (tested) red wire positive and black wire negative.

(b) Signal Hookup. 5 to 8 VDC (pulsed or square wave input) white wire positive and green wire negative. These wires can be interchanged without adverse effect on the system.

(2) DIP Switch Settings. The sending units used for this device were specifically tested for use in this unit. Other sending units are considered to be workable. Internal to the VMDM is a four-position DIP switch which sets the metering device to different configurations/modes. The DIP switch settings are shown on a label attached inside the instrument housing for the following functions:

(a) Independent Mode. This mode uses the internal 5 VDC power regulator in the VMDM to power the sending unit attached to it. Power input to the VMDM is 12 to 28 vdc from the vehicle electrical system. The switch settings for this mode are : SW1 - CLOSED; SW2 - OPEN; SW3 - OPEN; SW4 - Not Used.

(b) High Impedance Mode or Tachograph/VPR Mode. Sending units (successfully tested): Masstech yellow jacket switch TR-8 2525-8 which was used in conjunction with the VPR, and ARGO Instruments (Hall Effect sending unit) No. 2157 which was used with tachograph model 1310 or 1318. Both of these high impedance sending units generate 8 pulses/revolution output.

This mode slaves off of or is activated by either the ARGO Instrument tachograph Hall Effect sending unit or the Masstech yellow jacket switch sending unit. The power is supplied by either the tachograph or the VPR which are both powered by the vehicle electrical system. The switch settings for this mode are : SW1 - OPEN; SW2 - CLOSED; SW3 - OPEN; SW4 - Not Used.

(c) Low Impedance Mode. This configuration was designed to be slaved or powered off a low impedance pulse source. This configuration was not used or tested. A minor modification on the circuit, a resistor or capacitor change, may have to be made before this configuration is usable.

c. Vehicle Installation.

The sending units for the independent and high impedance modes were connected to the vehicle speedometer flexible shaft in one of two places: between the flexible shaft and the transfer case or between the flexible shaft and the speedometer.

2.5 TEST OF THE RE-DESIGNED METER

a. Bench Test.

The re-designed VMDM instruments were bench tested to determine the "full-on" miles per hour. The test was conducted using a test fixture (Figure 4) configured to rotate at an equivalent speedometer rate of 1 mph. One of the instruments was bench tested for accuracy. Two types of sending units were used.

(1) VMDM and ARGO Instruments Hall Effect sending unit No. 2157 (used with tachograph models 1310 or 1318), was tested for 20 hours. The ending VMDM reading was 20.1 hours.

(2) VMDM and Masstech yellow jacket sending unit (used with the VPR) was tested for 18 hours. The ending VMDM reading was 18.1 hours.

b. Field Test.

Four of the five re-designed VMDM instruments were installed in 5-ton class vehicles. These vehicles underwent 20,000-mile Initial Production endurance testing at YPG. The instruments were connected by slaving off the ARGO tachograph sending unit. As of 1 November 1988, the hours recorded on the four vehicles were: 834.6, 806.3, 762.1, and 379.5 respectively. The devices were monitored and evaluated at the end of each work shift.

2.6 RESULTS OF TEST

a. Bench Test.

The VMDM functioned satisfactorily.

b. Field Test.

The four meters functioned satisfactorily. By using the tachograph/VPR mode to connect the meter, the pulsing sequence that started the device activated and was at a "full-on" state at 0.7 mph.

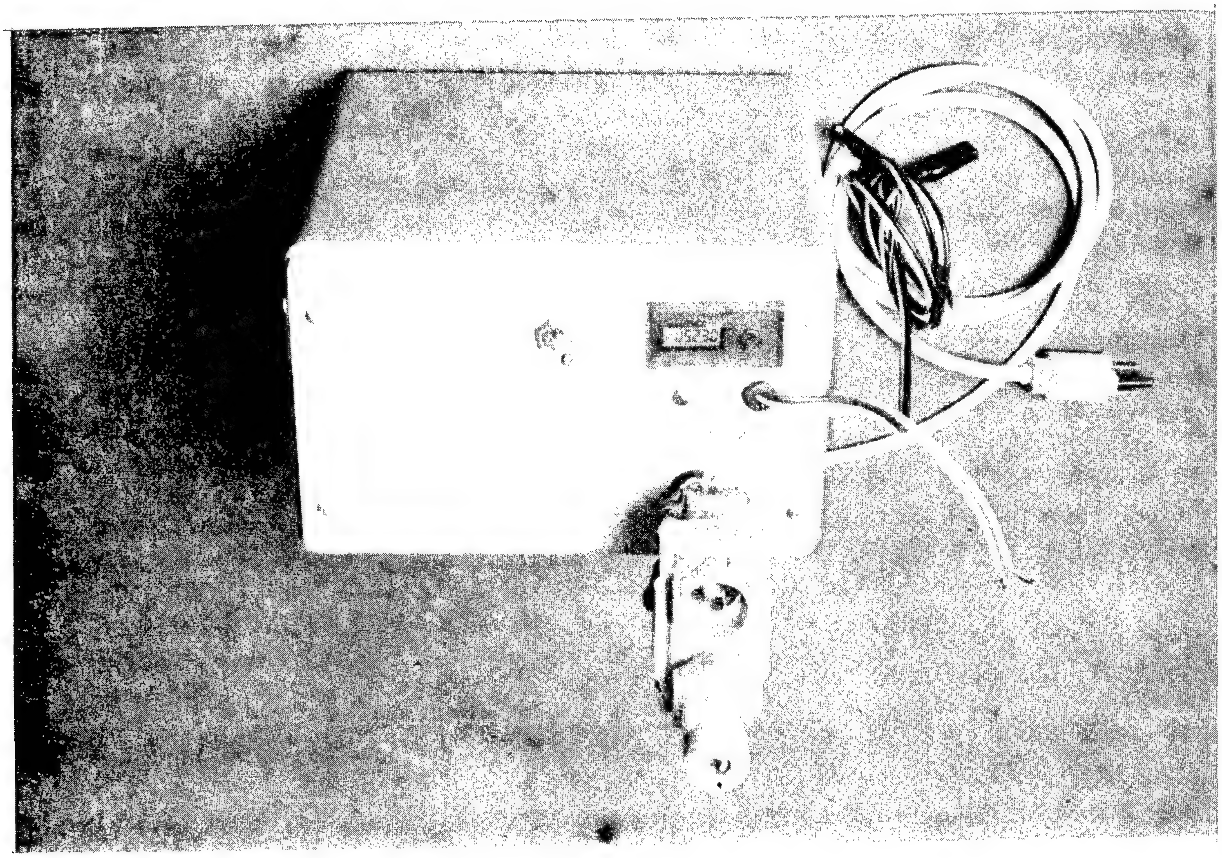


FIGURE 4. Bench Test Equipment.

2.7 ANALYSIS OF TEST

a. Bench Test.

The design modification improved the start or "full-on" state of the hour-meter from 1.4 mph to 0.7 mph. The pulse generation devices used with the VMDM generate 8 pulses per second. The industry standard speedometer cable rotation speed is 1000 rpm when recording 60 mph. This equates to an output of 2.2 pulses per second or an inter-pulse period of 450 ms at 1 mph. The worst case input encountered during testing was an inter-pulse period of 642 ms or an "full-on" state at 0.7 mph.

b. Field Test.

The results of the field test were satisfactory. The re-designed models of the VMDM provided statistically accurate forward/reverse vehicle movement data (in tenths of hours).

2.8 CONCLUSIONS

The VMDM can effectively perform its function. No shortcomings were noted with the design.

The VMDM provides reliable movement time data appropriate for statistical analysis of idle time, average speed, and operational failures.

The VMDM is less expensive to purchase/construct than the VPR system and will not loose data at power-off.

2.9 RECOMMENDATIONS

It is recommended that:

a. All vehicles undergoing research and development testing use the VMDM.

b. Future models of the VMDM should be constructed on a printed circuit board instead of using wire wrapped circuitry.

c. A resettable meter may further enhance the design of this device.

APPENDIX A.

DIRECTIVE

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is TAGO.

REFERENCE OR OFFICE SYMBOL	SUBJECT		
STEYP-MT-ET	Instrumentation Support--Moving Time Hour Meters		
TO	**FROM**	**DATE**	**CMT 1**
STEYP-MT-TS	TANK-AUTOMOTIVE BR	17 SEPT 87	

1. Request that four each moving time hour meters using electronic type hour meters be fabricated for use during the FA/IPT of M939A2 Series 5-Tons to start in early Nov. 87.

2. Request that four each electronic type hour meters also be provided for recording total operating time.

3. The hour meters should be readable to o.1 hour and total to 9999.9 hours.

4. Funds are available as follows:

    XO/WO 3703-2333-51
    PROJ NO 1-VG-120-939-010

5. Most all military wheeled vehicles have a speedometer drive cable that turns at 1000 revolutions per mile and it is assumed that this vehicle will have the same configuration, but this will be verified.

6. The automotive instrument lab has a variety of pulse type switches that can be installed in line with the speedometer cable that may act as a frequency source when the vehicle is in motion but of course the switch may remain in a closed position with the vehicle stationary.

7. Suggest that the moving time hour meter accrue operating time when vehicle speeds are above the range of speeds between 1 and 2 mph, with values closer to 1 mph being desirable.

Wayne Dailey

Wayne Dailey
Test Director

DA FORM AUG 80 2496 PREVIOUS EDITIONS WILL BE USED GPO : 1987 0 191-043

The actual waveforms are shown in Figures B-7 through B-14. A frequency generator signal input representing approximately four miles per hour were used. The actual time interval or inter-pulse period is dependent on the speed of the vehicle (real-time input signal). For the purpose of illustration, timing marks (T0, T1, T2) are given to show the time relationship between the various signal waveforms.

Timing marks TR and TR1 are given to show the timing relationship of the inter-actuation of the hour-meter's "on" indicator. These signal pulses (Figures B-13 and B-14) are strictly a function of the meter and have no timing relationship to the input signal (vehicle speed). However, it should be noted that the baseline voltage levels do indicate a "full-on" circuit state.

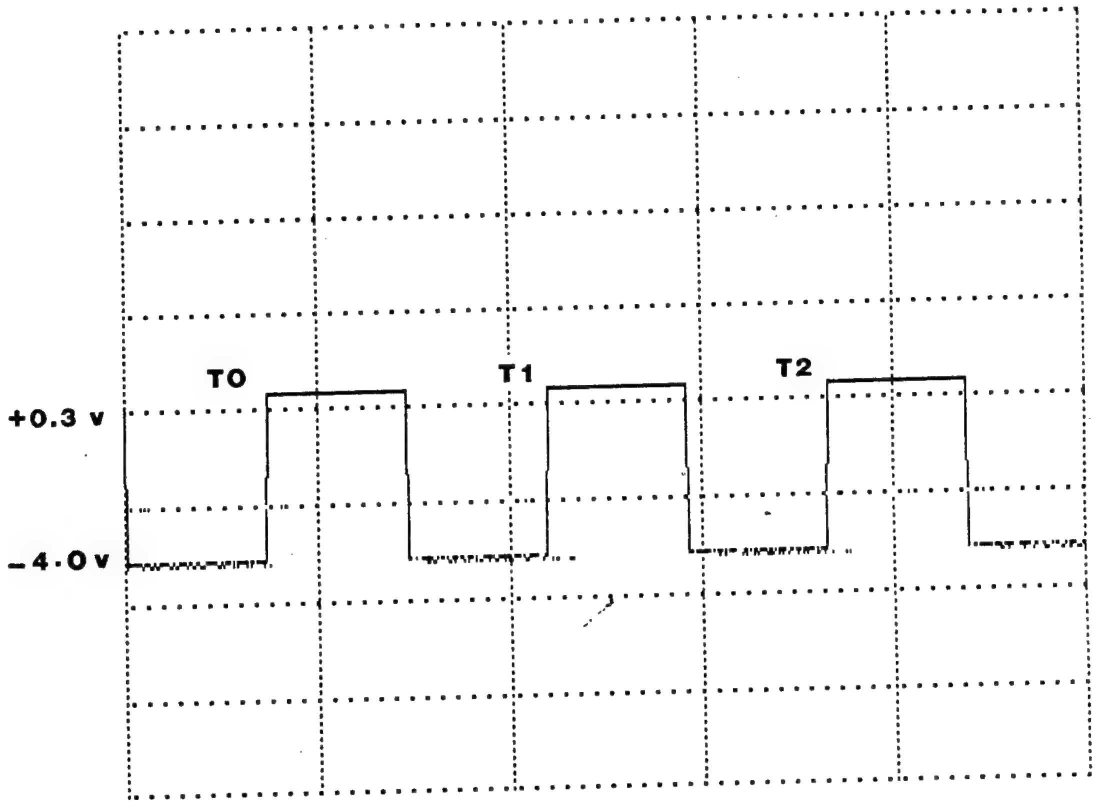


Figure B-7. Point J1 pin D.

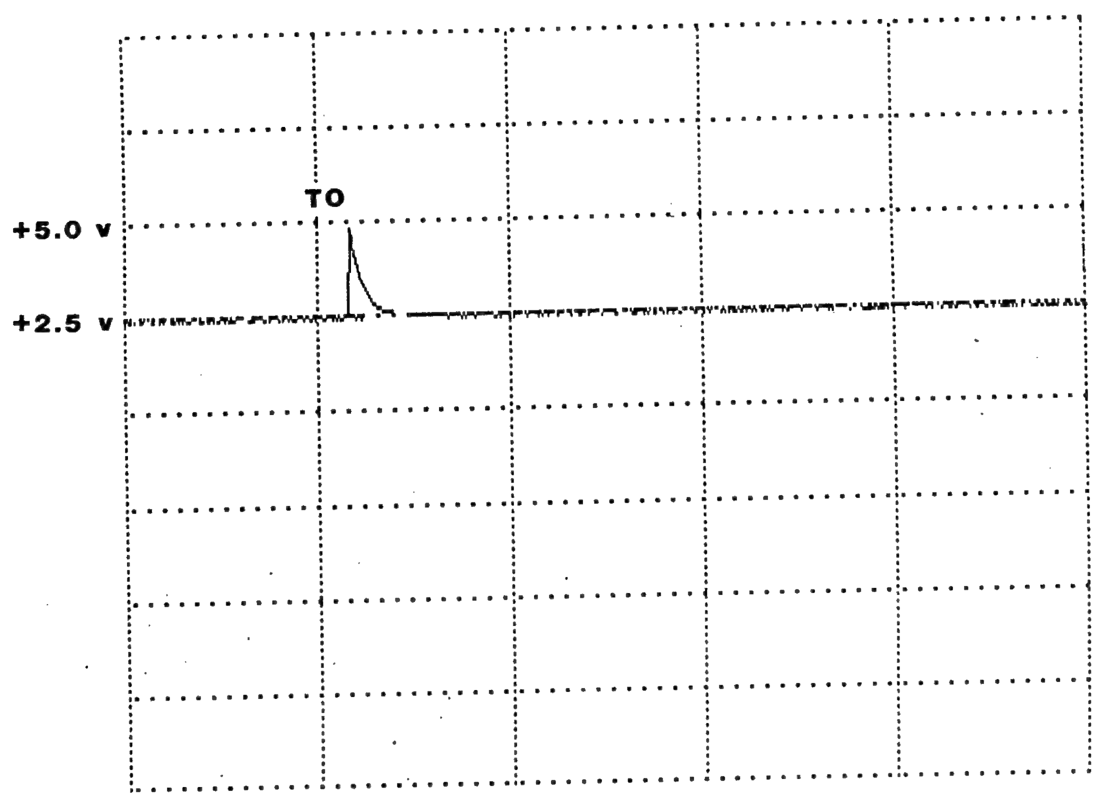


Figure B-8. Point U1 pin 13.

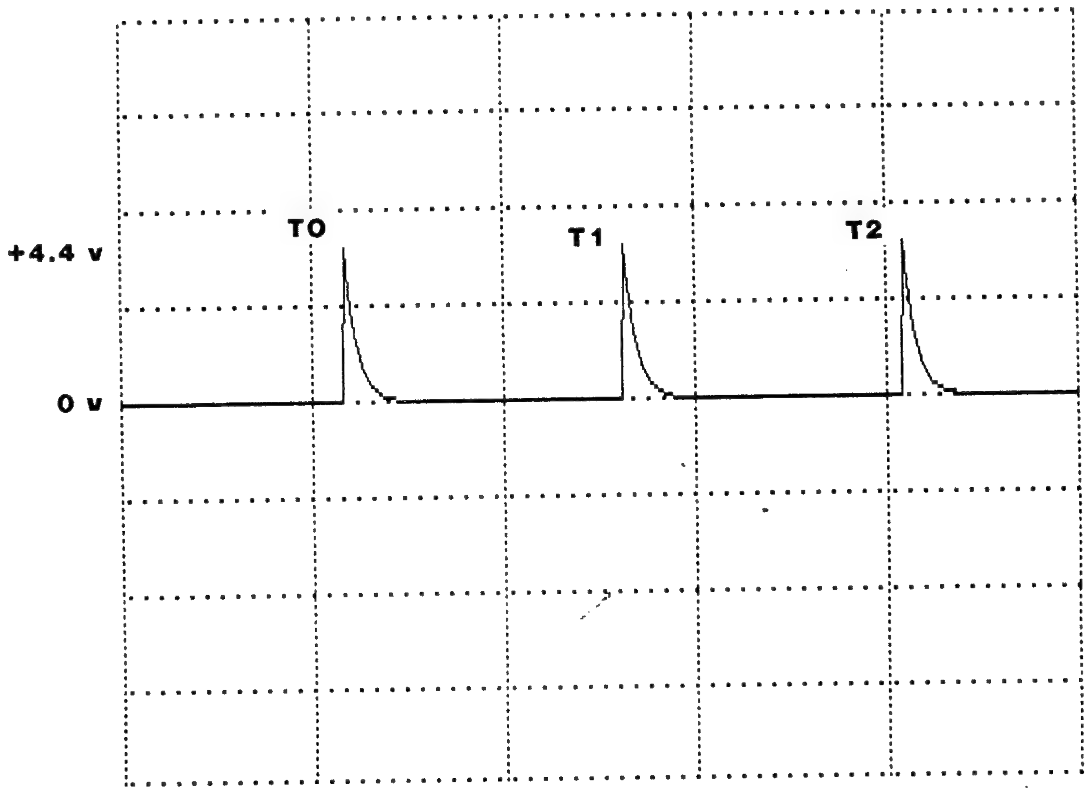


Figure B-9. Point U1 pin 3.

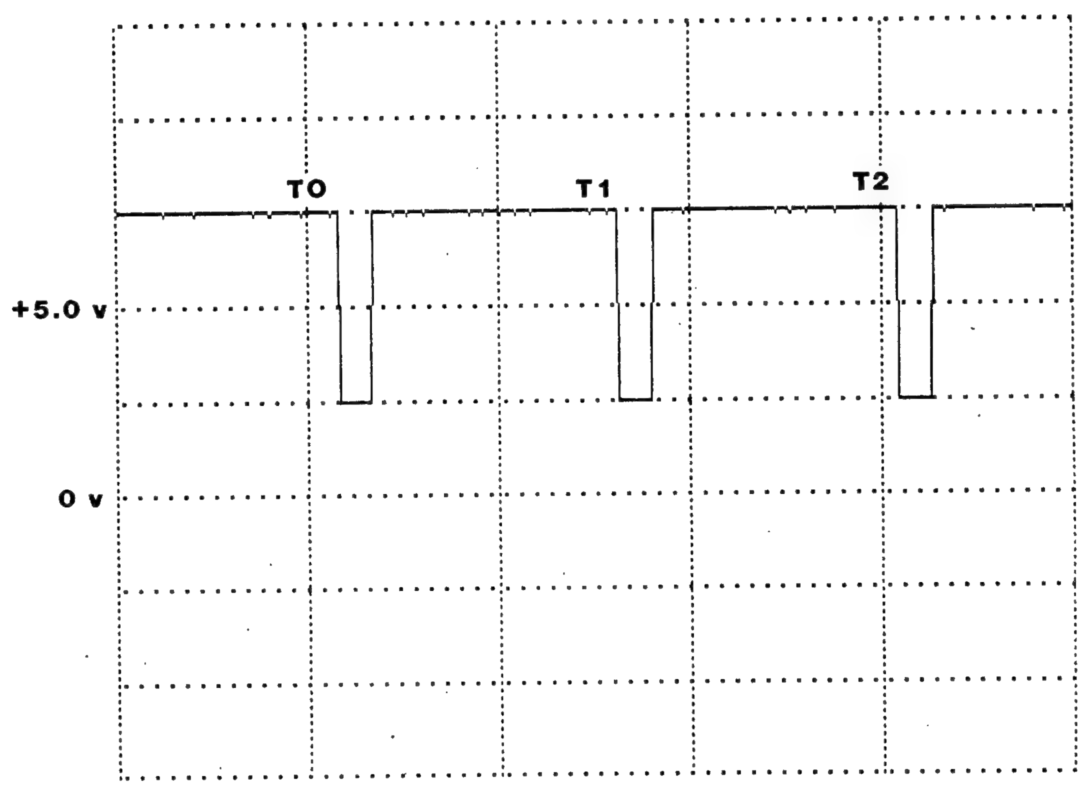


Figure B-10. Point U1 pin 4.

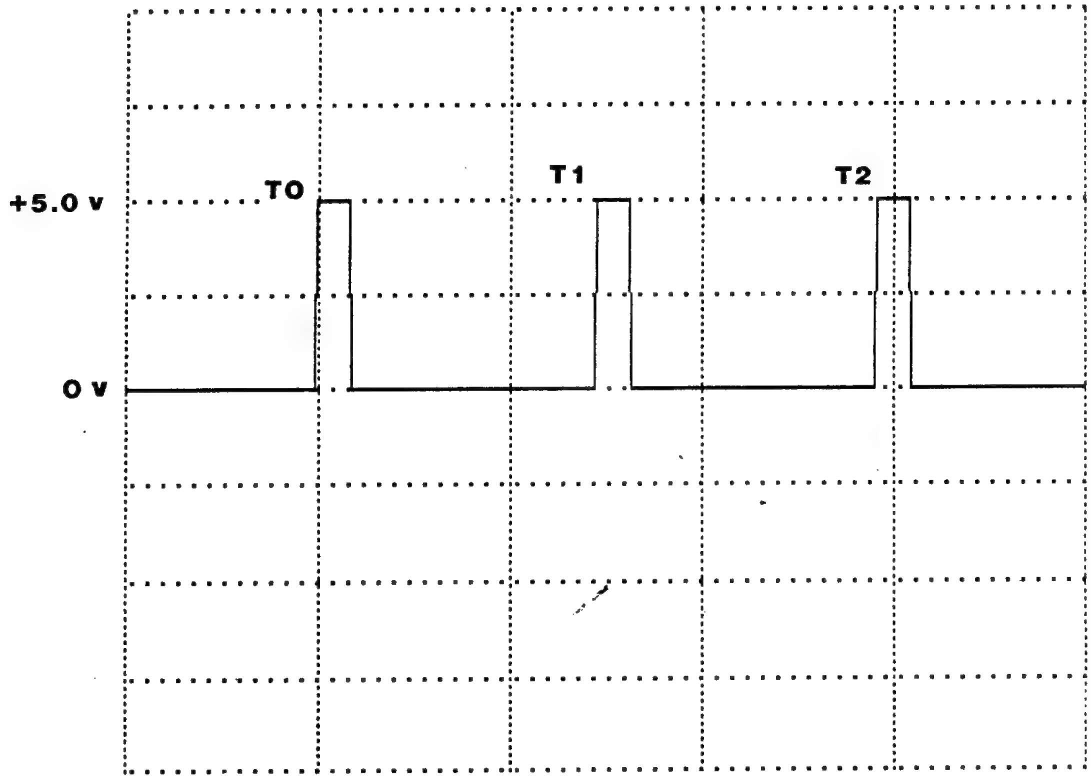


Figure B-11. Point U1 pin 6.

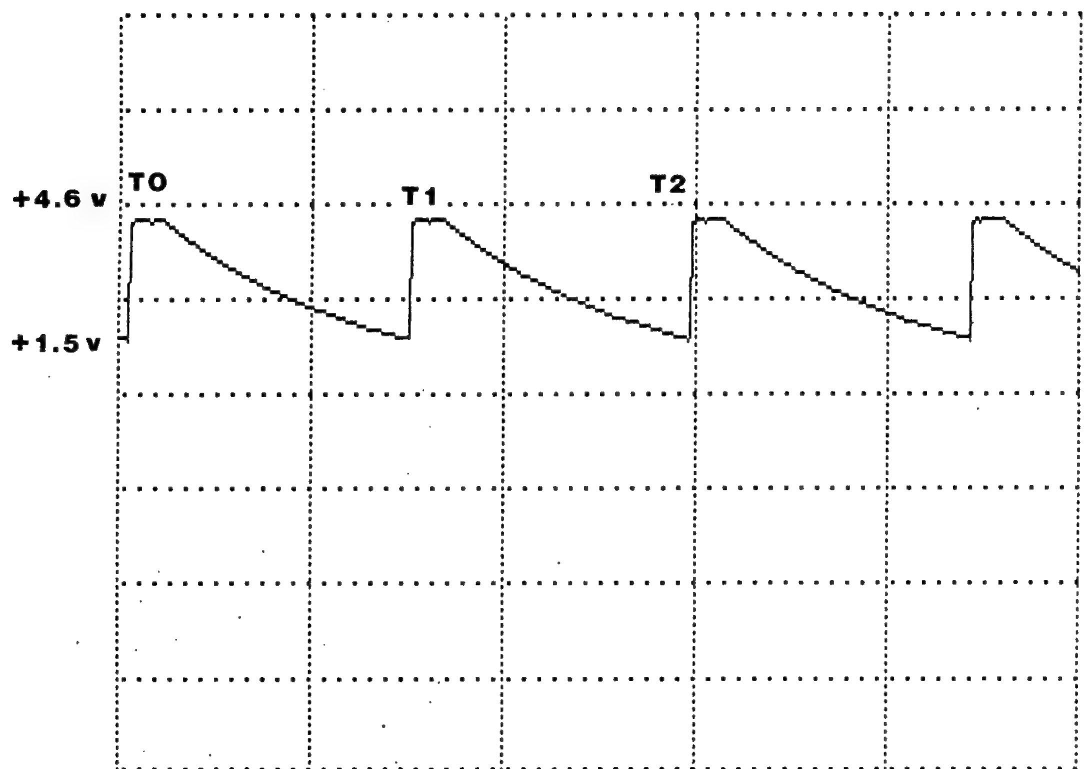


Figure B-12. Point U1 pin 11.

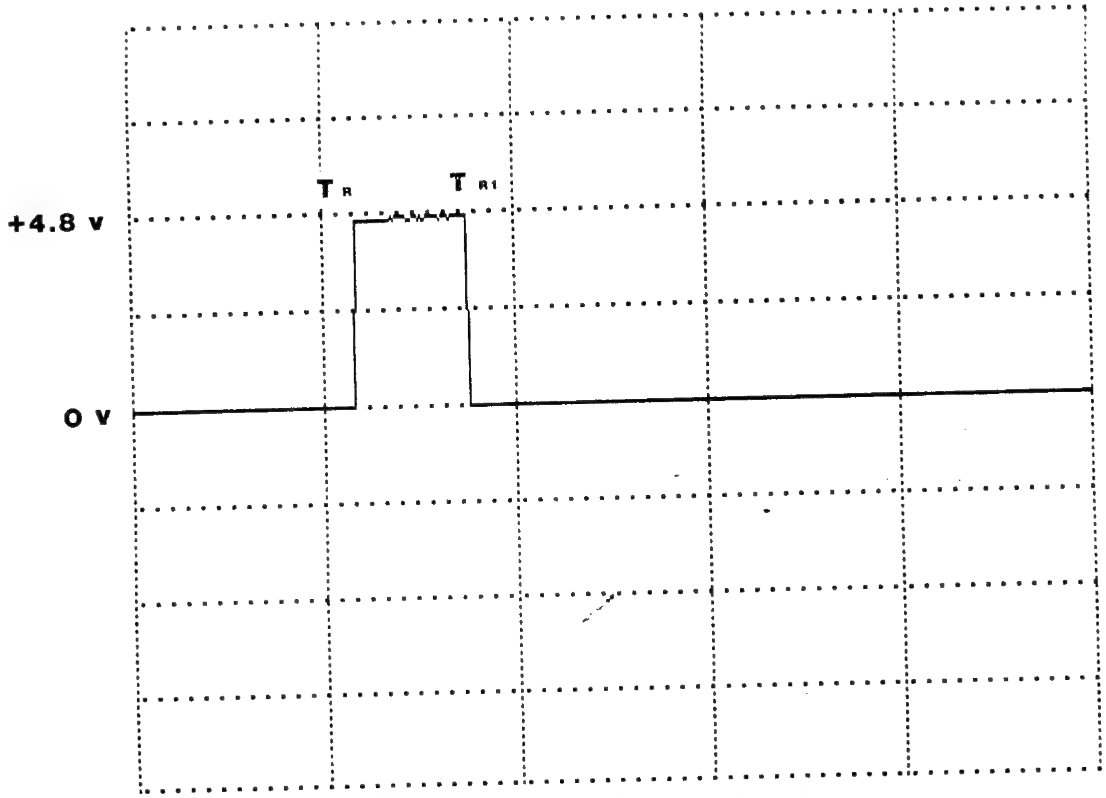


Figure B-13. Collector of Q1.

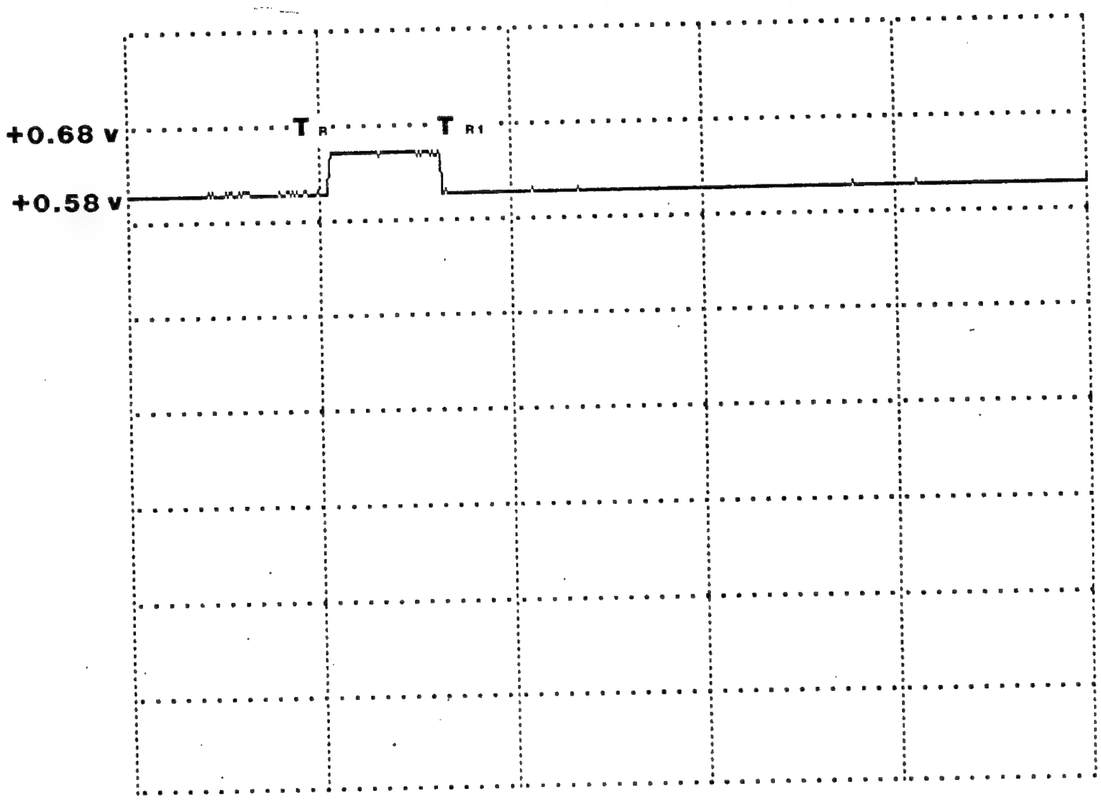
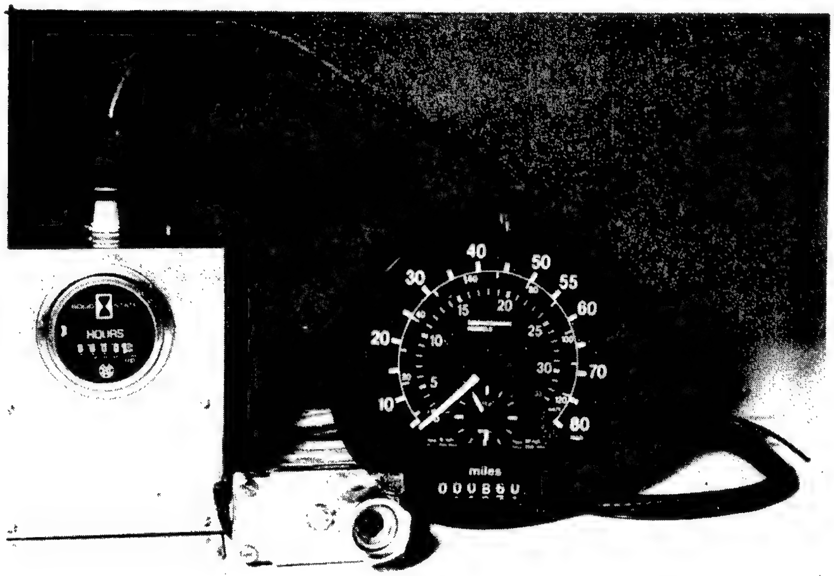


Figure B-14. Base of Q1.

APPENDIX C. ILLUSTRATIONS
INSTRUMENTATION CONFIGURATIONS



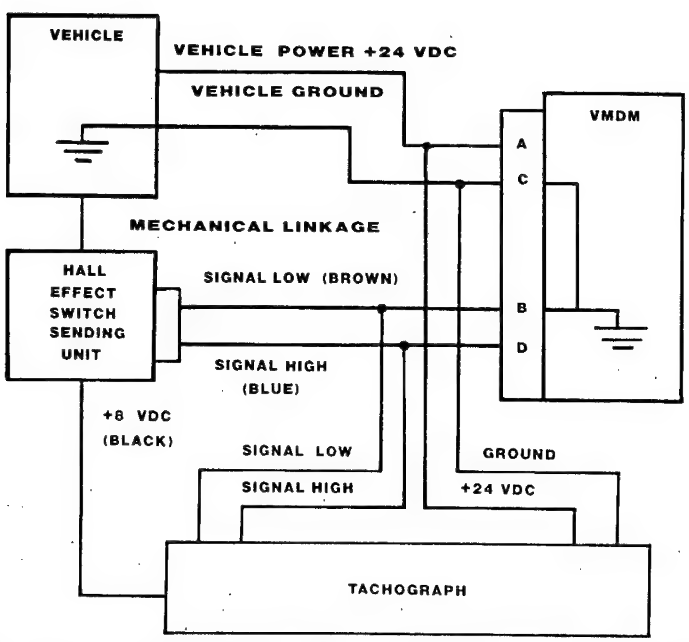


FIGURE C-1 HIGH IMPEDANCE MODE INSTALATION WITH TACHOGRAPH AND ARGO INSTRUMENTS 2157 HALL EFFECT SWITCH.

APPENDIX C. ILLUSTRATIONS
INSTRUMENTATION CONFIGURATIONS

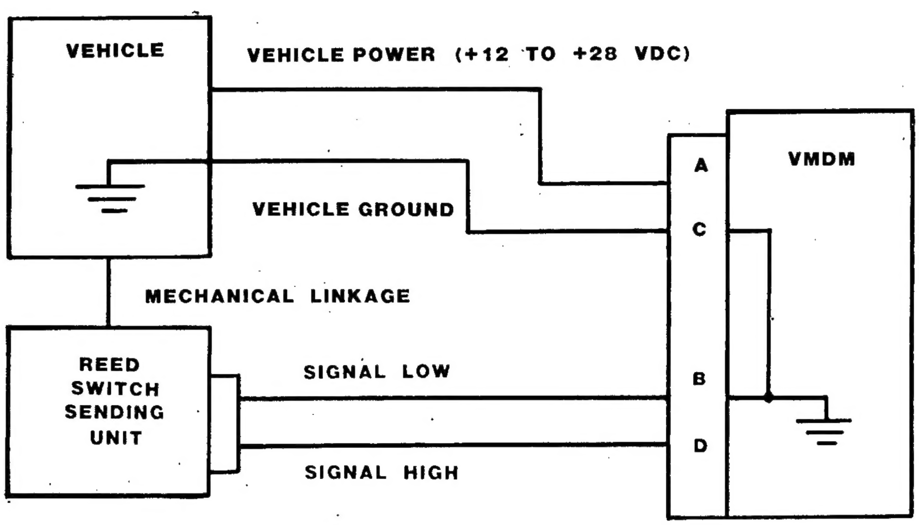
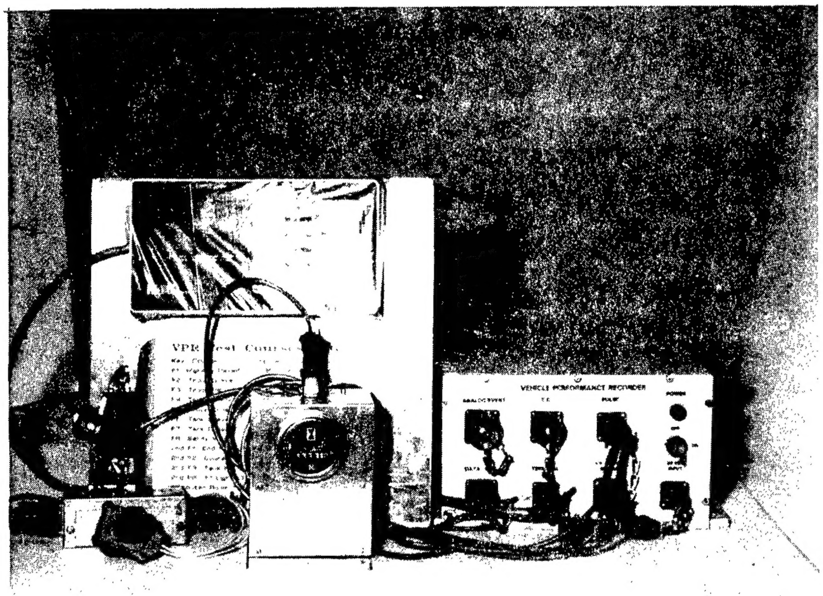


FIGURE C-2 INSTALATION WITH MASSTECH YELLOW JACKET REED SWITCH (TR-8 2525-8). (INDEPENDENT MODE)



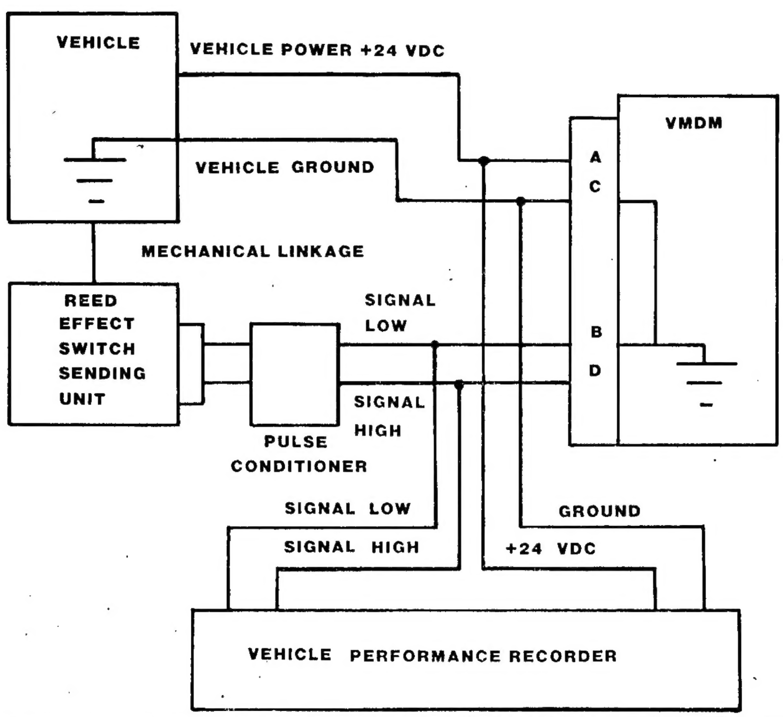


FIGURE C-3 HIGH IMPEDANCE MODE INSTALATION WITH VPR AND MASSTECH YELLOW JACKET SWITCH (TR-8 2525-8).

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